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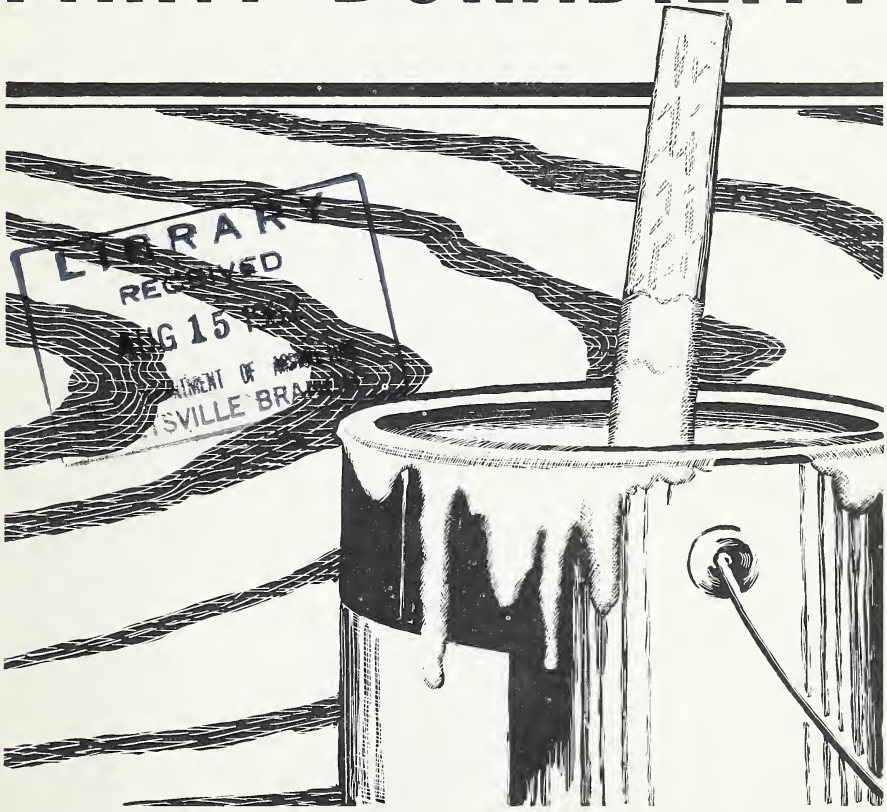
WOOD PROPERTIES AND PAINT DURABILITY



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Wood Properties And Paint Durability

By F. L. Browne, chemist, Forest Products Laboratory,[1] Forest Service

Savings can be effected in the overall costs of painting houses if woods with the most favorable properties are used. When less favorable woods are used, it is especially important that the best painting practices be followed the first time the woods are painted.

Outside house or barn paint lasts longer on some kinds of wood than on others. Some boards hold paint longer than others of the same kind of wood. The explanation of this behavior begins to appear when it is noticed that the original grain pattern of the wood gradually reappears as a coating of paint wears out and sloughs from certain parts of the wood surface (fig. 1). This publication describes some of the wood properties that affect paint service, how the more favorable woods and boards can be selected, and a few painting procedures that are helpful when the less favorable woods must be used.

The durability of paint coatings, of course, depends on other factors besides the nature of the wood painted. Among them are the nature and quality of the paint used, the skill with which painting is done, the proper spacing of repaintings, the extent to which the surfaces are sheltered from sun and rain (fig. 2), and climatic and local weather conditions. There are circumstances under which coatings may wear out or fail before there is time for the nature of the wood to show its effect. This publication, however, is concerned with the way in which wood affects the behavior of coatings of good paint, well applied and maintained, under ordinary conditions of service.

WOOD PROPERTIES THAT AFFECT THE LIFE OF PAINT

As a rule, the nature of the wood has little or no effect on the behavior of paint coatings until the coatings are old enough to show signs of serious wear. The wood properties that then become important are density and texture; content of resins, oils, and moisture; and such defects as knots.

DENSITY AND TEXTURE

The amount and distribution of summerwood govern the painting characteristics of a softwood (conifer) board. A tree adds an annual ring of new wood each year of its life. Each annual ring consists of springwood, formed early in the growing season, and summerwood, formed late. Summerwood is heavier, harder, smoother, darker in color, and is made up of

[1] Maintained at Madison 5, Wis., in cooperation with the University of Wisconsin.

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wood cells with thicker walls and smaller cavities than springwood. Oil from paint penetrates farther into summerwood than into springwood, but the oil that penetrates is separated from the coating and does not help to hold the coating in place. New paint sticks firmly to both springwood and summerwood. Old paint that has become brittle with age and weathering loses its adhesion and becomes dislodged from the smooth, hard surface of summerwood long before it parts from the rougher, softer springwood (fig. 1).

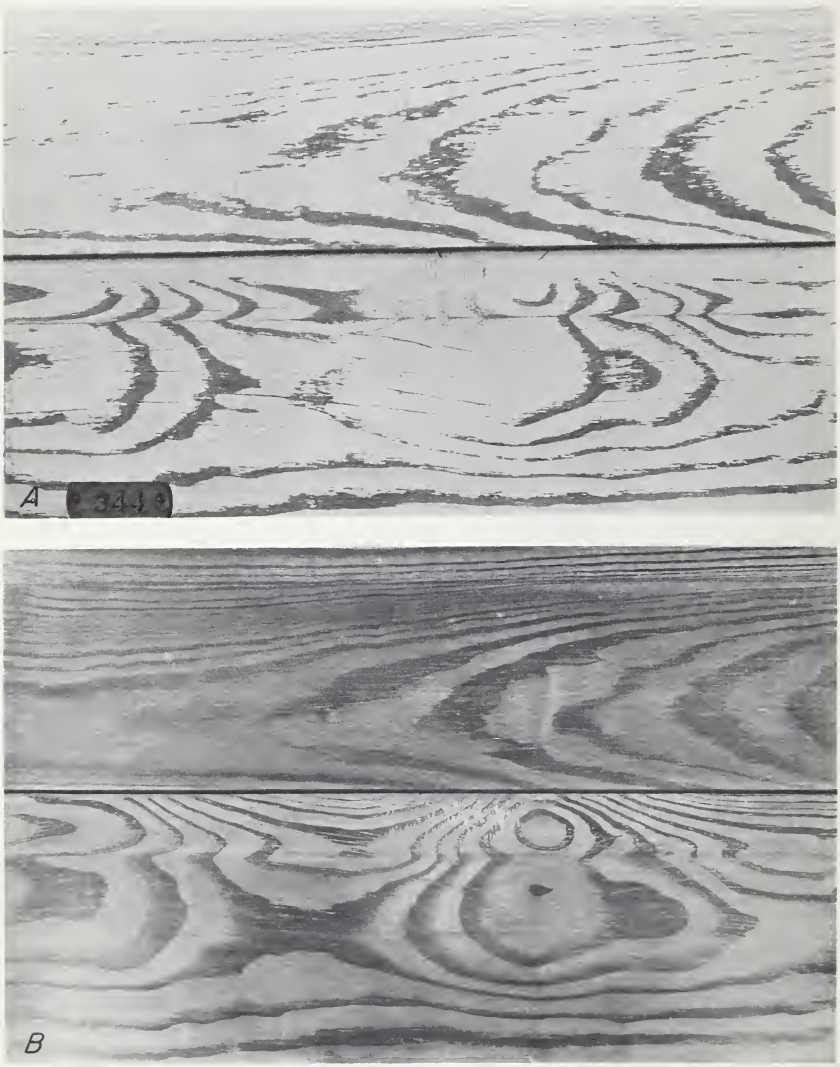

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FIGURE 1.—Paint fails soonest over the bands of summerwood in softwoods: *A*, Two boards that were painted with white paint and exposed to the weather for 5 years; *B*, the same boards after remaining paint was taken off with paint remover, showing the dark bands of summerwood, indicated by the paint-bare areas in *A*.

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FIGURE 2.—Paints last longer in shade than in strong sunshine. Two house paints (one at the left, another at the right) applied on Douglas-fir and southern yellow pine, after exposure to the weather for 8 years: *A*, facing south; *B*, facing north.

If the bands of summerwood are narrow enough, the coating may bridge the summerwood and remain in place longer than it can on wider summerwood bands. Boards with narrow bands of summerwood, therefore, are best for painting.

The width of the bands of summerwood in the faces of softwood boards depends on the density (weight per unit volume) of the wood, the width of the annual rings (rate at which the tree grew), and the manner of cutting the boards from the logs. High density is due to a high proportion of summerwood in the annual rings, which makes for wide bands. This may

be partly offset, however, if the tree grew slowly, so that its annual rings are narrow and there are many rings per inch of radius of the log. Figure 3 illustrates the interplay of density and ring count in their effect on the width of summerwood bands in the faces of boards. Finally, edge-grain or vertical-grain boards (called quartersawed in hardwoods) display much narrower bands of summerwood than flat-grain boards of otherwise similar wood.

Edge-grain boards are cut with their faces at right angles to the annual growth rings so that only the edges of the rings appear on the faces of the boards. Flat-grain boards, which are cut at a different angle, display the faces of the growth rings. In flat-grain boards, the side that was nearer the bark often holds paint longer than the opposite side.

Hardwoods (broad-leaved trees) are made up of fibers and pores whereas the softwoods have tracheids. The size and arrangement of hardwood pores, which are much larger than the fibers, may outweigh the other factors of density and texture in their effect on paint retention. Hardwoods such as oak, with pores larger than those in birch, are poorly adapted to ordinary house-painting methods because pinholes are left in the coating over the large pores. Pinholes are unsightly and lead to early failure of the coating. The best hardwoods for painting are those of medium to low density, such as yellow-poplar, with pores no larger than those in birch.

RESINS AND OILS

In well-seasoned wood, resins and oils have less effect on painting than is generally supposed. The resin in pine lumber shortens slightly the life

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FIGURE 3.—Paint-holding characteristics depend on wood texture and density. Boards *A* and *B* held house paint well, but boards *C* and *D* held it poorly when exposed to the weather. Board *A* had 36 annual rings per inch of radius of the log and at 6 percent moisture content weighed 25 pounds per cubic foot; board *B* had 27 annual rings and weighed 30 pounds; board *C* had 6 rings and weighed 30 pounds; and board *D* had 15 rings and weighed 46 pounds.

of paint containing zinc oxide, but this effect is avoided by using house-paint primer free from zinc oxide. Paint may dry slowly on baldcypress and some of the cedars when the wood is unusually rich in the characteristic oils, but the oils prolong the life of the coatings.

In green or inadequately seasoned lumber, however, resin may exude through paint coatings or may disrupt the coating when the wood is warmed by the sun or otherwise. Oils in unseasoned baldcypress or in some cedars may prevent the drying of some paints.

White or light-colored paint occasionally may acquire a yellow or brown discoloration over the heartwood of ponderosa pine or the white pines. The color comes from substances in the resin of the heartwood. This discoloration occurs usually on wood that is damp while being painted. It rarely occurs on dry wood.

MOISTURE CONTENT

As a rule the best time to paint wood is when it has about the average moisture content that is expected to prevail during service. For wood on houses, 12 to 15 percent moisture content usually is about right. Paints applied to very dry wood are slightly less durable.

It is seldom safe to paint wood in which the moisture content exceeds 25 percent because there is grave danger of failure of the coating by blistering (fig. 4) and peeling. Moreover, woods like redwood and redcedar, which contain colored substances soluble in water, may discolor paint applied while the wood is wet. Even if wood is dry when painted but later absorbs enough moisture to become wet, there is danger of blistering, peeling, or discoloration. Some paints, however, resist blistering and peeling better than others.

KNOTS AND OTHER DEFECTS

Knots in wood produce serious blemishes in paint coatings. In pine lumber the paint over knots is often discolored by yellow or brown substances from the wood. End-grain wood in the knots of any wood often absorbs enough oil from paint to destroy the gloss of the coating. Both discoloration and oil absorption can be prevented by applying shellac or other spirit varnish over the knots before painting, but the paint is likely to crack badly and may flake from the shellacked area before the coating wears out over the clear wood. Large knots are prone to crack even after they are painted, and the cracks may be too large to fill with new paint.

Pitch streaks or pitch pockets in wood mar paint coatings by causing the paint to crack or flake off, or by exuding resin.

Blue stain in sapwood can be concealed by paint as long as the wood can be kept dry. If at any time the wood becomes damp, however, the fungi causing the stain may become active and push through, discoloring the paint.

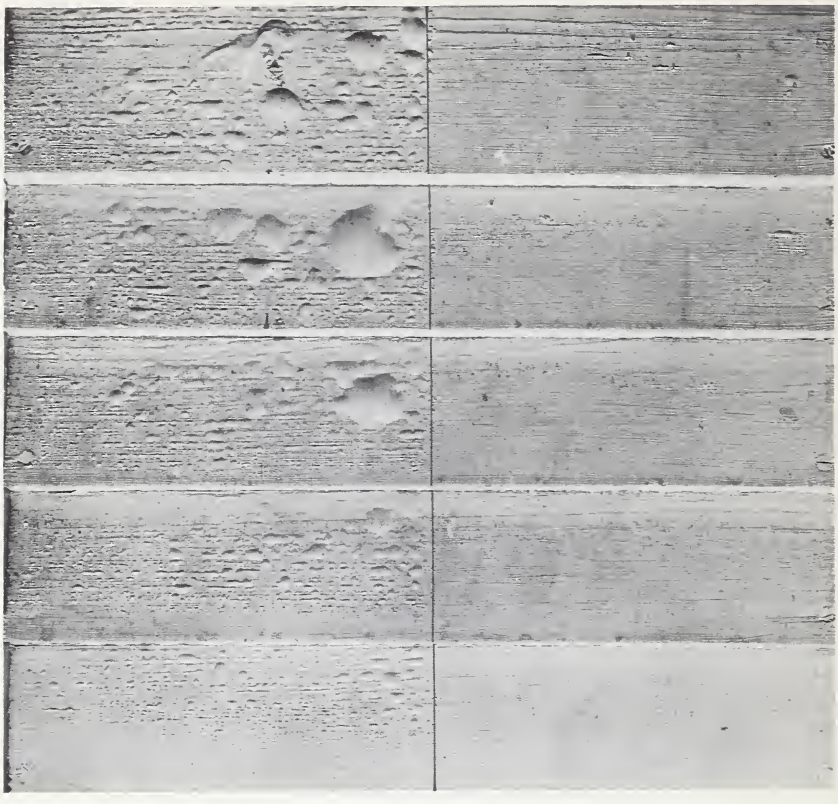

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FIGURE 4.—Blistering of paint coatings on wood siding caused by condensation of water behind the siding during cold weather. The badly blistered coating at the left consisted of three coats of good-quality house paint. The slightly blistered coating at the right consisted of two coats of the same house paint applied over a priming coat of aluminum house paint. Paint failures of this kind can be entirely prevented only by permitting no water to get behind painted woodwork.

SELECTING THE BEST WOOD FOR PAINTING

Wherever wood is to be kept well painted for a long time, the cost of paint maintenance can be reduced by selecting kinds of wood that hold paint coatings most satisfactorily (fig. 5).

SELECTION BY SPECIES

Since woods are marketed by species, selection begins with choice of species. The commercially important native woods, when purchased in lumber of the higher grades, are classified for painting characteristics into five groups:

Group I. Woods on which paints of the widest range in kind and quality give good service: the cedars, baldcypress, and redwood, all of which are softwoods.

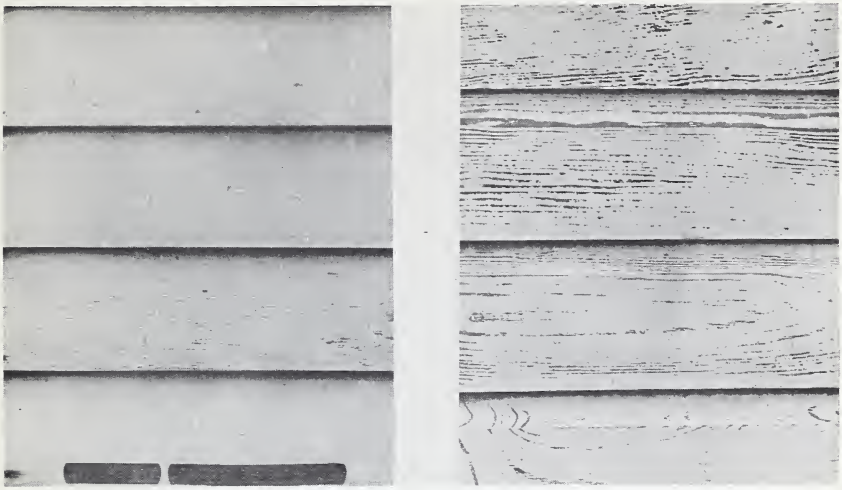

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FIGURE 5.—Paint wears longer on some woods than on others. The same good house paint as it appeared after 8 years of exposure to the north on western redcedar (two upper boards at left), on eastern white pine (two lower boards at left), on Douglas-fir (two upper boards at right), and on southern yellow pine (two lower boards at right).

Group II. Woods that require more care in the selecting of a suitable priming paint, such as pure white lead or a zincless house-paint primer: eastern white pine, sugar pine, and western white pine, all of which are softwoods.

Group III. Woods that are more exacting than those of group II but less exacting than those of group IV in requirements of suitable priming paint, finish paint of high quality, and careful program of maintenance: White fir, the hemlocks, ponderosa pine, and the spruces among softwoods; aspen, basswood, cottonwood, magnolia, and yellow-poplar among hardwoods.

Group IV. Woods that require the most care in the selection of suitable paints and that benefit especially from the use of aluminum house paint for priming the wood when first painted: Douglas-fir, southern yellow pine, and western larch among softwoods; beech, birch, the gums, and maple among hardwoods.

Group V. Woods that require wood filler in the pores before smooth coatings of paint or enamel can be applied: ash, chestnut, elm, hickory, oak, and walnut, all of which are hardwoods.

SELECTION BY GRADE

Most lumber is graded for sale. The higher the grade, the better the wood for painting because there are fewer defects, such as knots, pitch streaks, and pitch pockets, to impair paint service.

SELECTION BY KIND OF GRAIN

When edge-grain lumber is obtainable, it is better for painting than flat-grain lumber. The term "vertical grain" is sometimes used instead of edge-grain, and for hardwoods the term "quartersawed" is used. Not all species, however, are sold regularly in edge-grain. When flat-grain boards are used, it is desirable to turn them so that the bark side will be the surface exposed for painting. The bark side is the side toward which the annual growth rings are convex.

SELECTION BY DENSITY AND TEXTURE

In commercial shipments of many kinds of lumber, a wide range in density and in width of growth rings will be found. Paint maintenance can often be improved by setting aside those boards that are much above the average in weight or in width of summerwood bands. The heavy, wide-ringed boards may be used for construction that will not be painted, for less important parts of the structure, or for parts that will receive little sunshine. Paint lasts longer in shade than in sunshine (fig. 2). As a rule, the time for repainting a house is determined by the wearing out of paint on the poorest boards.

SUGGESTIONS FOR PAINTING THE HEAVIER SOFTWOODS

Some of the woods classed in groups III and IV are more abundant and less expensive than the woods in groups I and II. For that reason these more exacting woods will often be used for painting. For such woods, careful selection and application of paint in the first painting are most important.

Woodwork should be painted as soon after erection as possible, usually within a week. If, because of inclement weather, a much longer time is to elapse, lumber that has been treated with water-repellent preservative should be purchased or such treatment may be applied at the site. Siding or millwork that has already been primed at the factory is available sometimes, but the buyer may have no choice as to the kind or quality of the priming paint used. If woodwork is primed before erection, both sides of the pieces should be primed to avoid cupping or warping that might otherwise occur because of unequal changes in moisture content on the two sides. Although priming of butt ends is often omitted, it is better to paint butt ends with either primer or water-repellent preservative after cutting and fitting the boards but before fastening them in place.

Oil paint applied to woods of groups III and IV can be most durable if the woods are primed with aluminum house paint before house paint of the desired color is put on (fig. 6). The primer, however, must be aluminum house paint made specifically for exterior woodwork. Aluminum paint for metal, heat-resistant aluminum paint, aluminum lacquer, and so-called all-

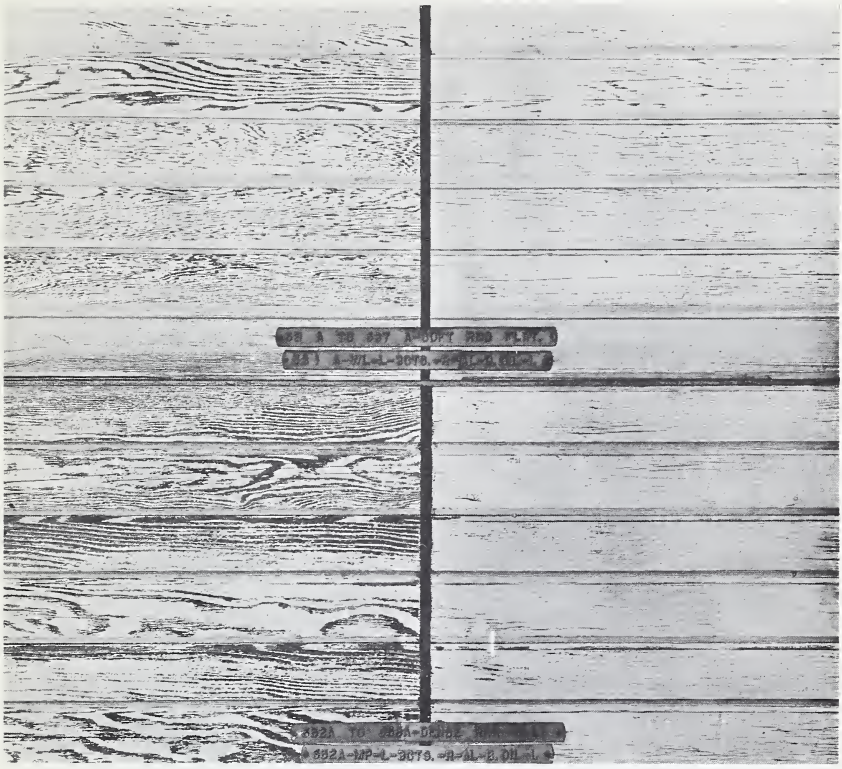

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FIGURE 6.—Aluminum priming paint improves the durability of house paints on woods that have wide bands of summerwood. These painted panels of Douglas-fir were exposed to the weather for 5 years, facing south. The left-hand halves were painted with three coats of white paint; the right-hand halves were painted with one coat of aluminum house paint followed by two coats of the same white paint that was used on the left-hand halves.

purpose aluminum paint are not satisfactory. The paint job consists of one coat of aluminum house paint followed by two coats of house paint of the oil type in the desired color and of a good quality. A single coat of house paint may not hide the gray color of the aluminum primer satisfactorily. So applied, white paint or any of the light colors should last about 4 years on woods of groups III and IV before repainting is necessary. Paints of dark color may last 2 or 3 years longer. When repainting, apply only the white or colored paint.

Next best to aluminum house paint for priming woods of groups III and IV are house-paint primers that contain no zinc oxide and that have the property commonly called "controlled penetration" (fig. 7). Nearly all paint manufacturers supply such primers.

Although two coats of oil paint, one of primer and one of finish paint, have become the general practice for new work, a third coat of the finish paint will more than repay its cost in longer and better service. House paints

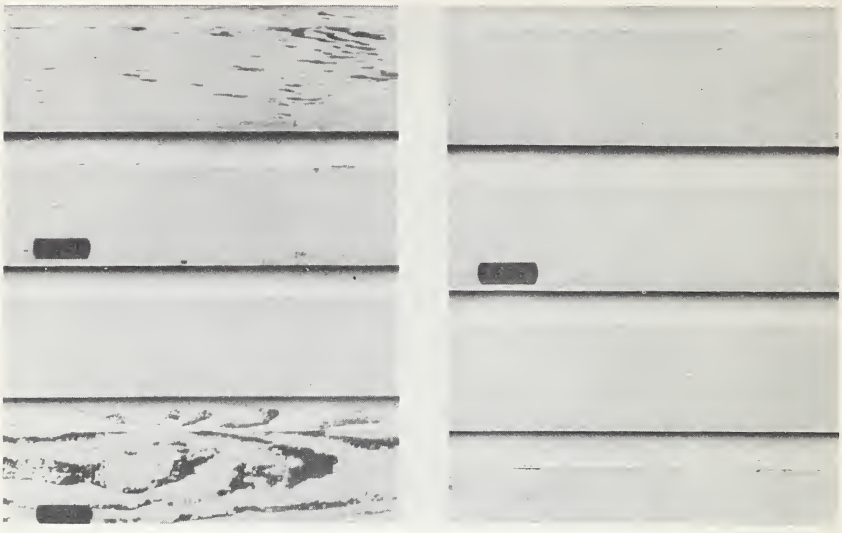

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FIGURE 7.—House-paint primer improves the durability of paint on woods of group IV. Panels at the left and at the right are adjacent areas of the same boards of Douglas-fir (first and third boards from the top) and of southern yellow pine (second and fourth boards). The panel at the left was painted with two coats of white paint; the panel at the right was painted with one coat of special primer and one coat of the same white paint. Panels were exposed to the weather, facing south, for 3 years.

of the oil type serve best when the dried coating is from 4.5 to 5 mils (1 mil is 0.001 inch) thick. On the other hand, subsequent repaintings should be limited whenever possible to a single coat of finish paint after the previous coating has become well worn. Repainting too frequently and with too much paint at one time makes coatings too thick to serve satisfactorily.

When the relatively new emulsion paints, which are thinned with water, are selected, the use of a priming paint recommended by the paint manufacturer is especially important. An oil-type priming paint commonly is advised for painting wood that has not been painted previously and is often advised for repainting over old paint as well. Two finish coats of emulsion paint rather than one only are usually suggested, moreover, because the emulsion paints leave much thinner coatings than the oil paints do. Even with one coat of oil primer and two of finish paint, the coating with emulsion paint is unlikely to attain the minimum thickness of 4.5 mils recommended for oil paints.

The best paint service is most easily obtained when wood of the most favorable kind is selected. But if care is exercised in the selection of paints and good painting methods are followed, it is possible to obtain good results even with the more exacting woods.

Additional information may be found in Home and Garden Bulletin No. 52 "Wood Siding—How To Install It, Paint It, Care for It," issued October 1956.

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